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THE WORK OF THE HUNTLEY RECLAMATION PROJECT EXPERIMENT FARM IN 1920

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Milk Cows on Irrigated Pasture, Huntley Experiment Farm.

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EXTENT AND CHARACTER OF THE WORK.

The Huntley Experiment Farm is located on the Huntley Reclamation Project in the Yellowstone Valley, Mont. The farm includes about 300 acres of land, of which about one-half is irrigated. The investigational work includes field experiments under irrigation and on the dry lands, as well as some experiments in crop utilization through the use of live stock. The agronomic work was begun in 1909, and the live-stock experiments were begun in 1917.

The farm is maintained cooperatively by the Office of Western Irrigation Agriculture of the Bureau of Plant Industry and the Montana Agricultural Experiment Station. Various offices and divisions of the Department of Agriculture, in both the Bureau of Plant Industry and the Bureau of Animal Industry, as well as the departments of the Montana Experiment Station, cooperate in the investigational work.

The experiments with crops relate mainly to tests and methods of production of crops of importance locally, although many of the results should be applicable to those irrigated sections of Montana and Wyoming where similar conditions of soil and climate prevail. The most important line of investigation with crops under irrigation is a series of crop-rotation experiments which were begun in 1912. Work with dry-land crops also includes rather complete experiments in crop rotations and tillage methods. Some of the outstanding results in these rotations on both irrigated and dry land are treated in this report. Other lines of investigation with irrigated crops are varietal test of grains and forage crops; pasture-grass experiments; tests of silage crops; and tests of fruit trees, small fruits, and vegetables.

Experiments in crop utilization include work with dairy cattle and hogs. The work with dairy cattle includes carrying-capacity tests of

three pasture mixtures on irrigated land and tests of various locally grown feeds for winter use. The pasture carrying-capacity test was begun in 1918, so that the results of three years are available, which give fairly definite indications of the value of irrigated pastures. Tests of milk and butter-fat production for advanced registry, in which the cows are carried on roughage alone during one lactation period and on roughage and grain during a second lactation period, are being conducted. Holstein bulls from the station herd are loaned, under contract, to local farmers, and eight such animals are at present in service. The experiments with hogs include tests of various quantities of grain and other concentrates as supplements to alfalfa pasture and of methods and feeds for finishing hogs in the dry lot.

CONDITIONS ON THE PROJECT.

CLIMATIC CONDITIONS.

The total annual rainfall for 1920 was 13.80 inches, 0.15 inch less than the average for the past 10 years. Of the total, 12.75 inches occurred during the first eight months of the year, and in each of these eight months the rainfall was above normal. The precipitation during the summer months, although high, occurred in the form of torrential showers and was of but slight benefit to crops.

Heavy snowfalls occurred during the winter, and extreme low temperatures were recorded. The minimum temperature of −37°, on March 5, was the lowest recorded for this month since observations at the station began.

The date of the last killing frost was June 3 and of the first September 24, so that the frost-free period was 112 days, as compared with an average of 127 days for the 10-year period. The climatological observations as recorded during the 10-year period from 1911 to 1920, inclusive, are given in Table I.

CROP CONDITIONS.

Yields of the principal crops—alfalfa, sugar beets, and wheat—were below the average of former season, being even less than in 1919, which season was considered to be rather unfavorable, especially for sugar beets and grain. Alfalfa fields were damaged rather seriously on most parts of the project through winterkilling, the greatest damage occurring in the older fields or those seeded previous to 1919. With unfavorable weather conditions during the spring months planting was much delayed, and on most parts of the projects, especially on the heavier soils, field work was not possible until about May 15 because of continued rains. A period of drought and hot weather followed planting, and it became necessary in many cases to resort to irrigation to provide moisture for germination.

This condition more than any other was probably responsible for the unsatisfactory yields of sugar beets. Stands of beets were very often poor, and the crop was much delayed in starting, so that the growing season was short.

TABLE I.—*Summary of climatological observations made at the Huntley Experiment Farm for the 10-year period from 1911 to 1920, inclusive.*

PRECIPITATION (INCHES).

Item.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Average for 10 years, 1911 to 1920	0.65	0.34	0.71	0.98	2.24	2.40	1.32	0.83	1.52	1.38	0.78	0.80	13.95
For 1920	.75	1.28	1.17	2.03	2.47	2.46	1.58	1.01	.32	.20	.05	.48	13.80

EVAPORATION (INCHES).

Average for 10 years, 1911 to 1920	.....	.....	.....	3.353	4.806	6.371	7.630	6.811	4.245	.....	.....	.....	33.216
For 1920	.....	.....	.....	1.975	4.700	5.769	7.512	7.236	4.571	.....	.....	.....	31.763

DAILY WIND VELOCITY (MILES PER HOUR).

Highest:													
1911 to 1920	22.2	14.1	13.3	17.8	17.5	10.2	8.6	7.3	10.5	29.4	25.0	26.6	.....
For 1920	22.2	9.4	10.3	10.9	10.0	4.9	5.8	7.0	6.9	8.2	9.0	12.6	.....
Lowest:													
1911 to 1920	.3	.8	.5	.9	.9	.4	.3	.3	.4	.8	.5	.1	.....
For 1920	1.6	2.0	1.7	.9	2.5	1.7	.6	1.6	.7	1.3	1.0	.2	.....
Mean:													
1911 to 1920	5.6	4.7	4.1	5.4	5.1	4.1	3.4	3.4	3.7	4.1	4.4	4.9	.....
For 1920	6.6	5.0	5.0	5.0	5.0	3.4	3.4	3.5	3.2	3.7	3.7	4.1	.....

TEMPERATURE (°F.).

Absolute maximum:													
1911 to 1920	65	63	74	87	99	107	103	103	94	90	71	63	.....
For 1920	54	57	66	68	86	91	100	103	94	90	64	54	.....
Absolute minimum:													
1911 to 1920	−39	−38	−37	12	22	32	38	34	24	−10	−21	−41	.....
For 1920	−31	− 9	−37	14	29	32	47	42	25	12	−11	−26	.....
Mean:													
1911 to 1920	18	22	32	45	54	64	71	68	57	44	33	22	.....
For 1920	22	27	29	38	53	62	73	70	59	47	31	24	.....

KILLING FROSTS.

Year.	Last in spring.		First in autumn.		Frost-free period (days).
	Date.	Minimum temperature (°F.).	Date.	Minimum temperature (°F.).	
1911	May 26	32	Sept. 18	28	114
1912	May 12	28	Sept. 15	31	125
1913	May 5	31	Sept. 19	29	136
1914	May 12	32	Oct. 6	31	146
1915	May 21	32	Sept. 19	32	120
1916	May 16	30	Sept. 13	31	119
1917	May 31	31	Sept. 28	32	119
1918	May 21	32	Oct. 7	28	138
1919	May 7	29	Sept. 27	32	142
1920	June 3	32	Sept. 24	32	112
Average	May 19	.....	Sept. 24	.....	127

The first cutting of alfalfa hay was seriously damaged by a heavy rain at the time of harvest, but the second and third crops were cured in good condition. Damage to crops by hail occurred during the early part of July in some parts of the valley.

Alfalfa in 1920 occupied about the same acreage as in 1919. The total yield of alfalfa in 1920 was, however, about 2,000 tons less than in 1919, and the acre value was $17.94 as compared to $52.22 in 1919. The acreage in sugar beets was about twice that of 1919, although the average yield was only 6.36 tons per acre, as compared to a yield of 10.58 tons per acre in 1919. The area devoted to wheat was less than in 1919 by about 1,300 acres. Table II indicates that the total cropped area was 20,021 acres, which was a slight increase over that of 1919. The total value of all crops produced was $543,781, as compared to $948,968 in 1919. The crop value per acre was $27.11, while in 1919 it was $49.14.

TABLE II.—*Acreage, yields, and farm values of crops produced on the Huntley Reclamation Project in 1920.*

Crop.	Area (acres).	Unit of yield.	Yields.			Farm values.		
			Total.	Per acre.		Per unit of yield.	Total.	Per acre.
				Average.	Maximum.			
Alfalfa hay	7,468	Ton	16,962	2.27	6	$7.90	$134,000	$17.94
Alfalfa seed	12	Bushel	4	.33	.33	24.00	96	8.00
Barley	324	do	4,816	14.82	57	.89	4,286	13.23
Beets	2,330	Ton	14,814	6.36	15.5	12.00	177,769	76.29
Clover hay	54	do	99	1.83	3	10.75	1,064	19.70
Clover seed	142	Bushel	305	2.15	5	7.30	2,227	15.69
Corn	392	do	4,441	11.33	70	.81	3,597	9.18
Garden	181						16,667	92.08
Oats	1,764	Bushel	40,960	23.22	106	.67	27,443	15.55
Pasture, summer	2,074						18,136	8.74
Pasture, winter	15,550						28,301	1.82
Potatoes	78	Bushel	6,449	82.68	450	1.11	7,158	91.77
Wheat	5,098	do	83,549	16.38	40	1.44	120,641	23.54
Miscellaneous	104						2,996	28.80
Beets	53						(1)	
Oats	84						(1)	
Alfalfa	35						(1)	
Corn	64						(1)	
Barley	38						(1)	
Wheat	252						(1)	
Total	20,021						543,781	
Average								27.11

[1] No crop value, although included in above report.

The evolution of the Huntley Reclamation Project with respect to the major crop industries is set forth in Table III, which gives the total cropped acreage of the project for each of the last eight years, together with the acreage devoted to each of the more important crops or groups of crops. This table shows that alfalfa continues to be the most important crop on the project, occupying fully one-third of the total cropped acreage. Since 1917, wheat has been second in importance to alfalfa, having displaced the sugar-beet crop from

that position despite the high prices paid for beets during the past few years.

One of the noticeable features of the cropping system of the Huntley project is the small acreage of potatoes. With about 550 farms on the project, the total potato acreage reported is barely sufficient to produce the local requirements. This small acreage is rather surprising, in view of the fact that under good farming potatoes yield very well on Huntley soils. On the experiment farm the average yield of all potato plats in the rotation experiments, 17 plats each year, has been 237 bushels per acre. Though the average yield reported for the farms on the project has been somewhat less than half as much, there have been numerous reports of yields of more than 300 bushels per acre. In view of these facts, it would seem

FIG. 1.—An irrigated pasture on the Huntley Reclamation Project in which 5½ acres of mixed grasses and clovers supported from 11 to 14 head of stock during the second year.

worth while in considering the future development of the project to test the possibility of a larger acreage of potatoes. The crop is one that fits in well in combination with alfalfa, grain, and sugar beets, and while the product is subject to prononuced fluctuations of price from year to year, it is proving an important feature of the agriculture of other irrigated areas on the northern Great Plains.

Another feature of the agriculture of the Huntley project, but one which is not shown in Table III, is the increasing use of mixed-grass pastures for dairy cows and sheep. Within the past four years there has been a rapidly increasing interest in the establishment of irrigated pastures (fig. 1). It has been demonstrated on the experi-

ment farm, and also by a number of farmers, that the returns obtained from good irrigated pastures compare favorably with those from any other crops. It has been shown that such pastures provide feed sufficient to carry two cows per acre for four and one-half to five months of the year, and that the cows do better and require less labor for care than if they are kept in a corral and fed hay.

TABLE III.—*Acreage of crops on the Huntley Reclamation Project during the 8-year period from 1913 to 1920.*

Item.	1913	1914	1915	1916	1917	1918	1919	1920
Alfalfa and other hay	5,183	6,464	5,729	5,762	6,491	6,972	7,247	7,569
Wheat	1,177	1,663	2,869	2,624	5,306	6,306	6,664	5,350
Other small grain	4,180	3,606	2,958	2,926	2,535	2,081	2,296	2,126
Sugar beets	4,475	4,274	5,402	5,264	3,366	1,963	1,136	2,383
Corn and fodder	326	553	527	215	253	203	179	456
Potatoes	99	120	80	54	164	73	40	78
All other crops	358	388	638	1,736	989	1,667	1,758	2,059
Total area cropped	15,798	17,068	18,203	18,581	19,104	19,265	19,320	20,021

CONDITIONS RELATING TO LIVE STOCK.

The character and extent of the live-stock industries remained about the same as in the previous three or four seasons. The fact that the price of feeds and such cash crops as wheat and sugar beets remained at a relatively high level during this period tended to discourage any expansion in any branch of live-stock production, although it is clearly recognized that the keeping of some class of live stock is necessary in order to maintain a permanent and successful agriculture. With the return of more nearly normal conditions there is indication of greater interest in live stock, particularly in dairying, for which conditions appear to be especially well suited.

TABLE IV.—*Live stock on the Huntley Reclamation Project in 1920.*

Item.	Inventory, Jan. 1.			Inventory, Dec. 31.			Decreased total value.
	Number.	Average value.	Total value.	Number.	Average value.	Total value.	
Horses	2,297	$110.00	$252,670	2,041	$88.90	$181,445	$71,225
Mules	46	81.50	3,749	34	94.40	3,210	539
Cattle:							
Beef	2,631	47.70	125,498	1,312	42.90	56,416	69,082
Dairy	2,040	62.30	127,092	1,804	63.45	114,464	12,628
Sheep	2,115	8.40	17,766	2,352	6.19	14,745	3,021
Hogs	3,097	13.64	42,242	1,885	11.15	21,018	21,224
Fowls	21,456	.66	14,162	18,232	.69	12,680	1,482
Bees, hives	458	5.35	2,450	180	7.30	1,314	1,136
Total			585,629			405,292	180,337

The raising of hogs, while never extensive, has, owing to present unfavorable market conditions, suffered a further decline during the year.

The number of sheep on the project was 2,362, and most of these were brought in for winter feeding. As reported by the United States Reclamation Service, the total value of all live stock on the Huntley project in 1920 was $405,292, a decrease of $180,337 since 1919. This decrease was due not so much to a reduction in the number of live stock as to the difference in estimated value per head of animals. Table IV, which is compiled from information furnished by the United States Reclamation Service, gives the total number and value of live stock on the project in 1920.

CROP-ROTATION EXPERIMENTS.

Crop-rotation experiments under irrigation occupy 70 quarter-acre plats in field K and 27 quarter-acre plats in field L–IV (fig. 2). The experiments in field K were begun in 1912 and those in field L–IV in 1916. These experiments include eleven 2-year, five 3-year, four 4-year, and six 6-year rotations in which the crops—alfalfa, oats, wheat, sugar beets, potatoes, corn, and flax—are grown in various sequences. Each of these crops is also grown continuously on the same plat each year.

TABLE V.—*Average, maximum, and minimum yields of all crops in the irrigated rotations on the Huntley Experiment Farm in 1920, compared with the average yields of the same crops in the 7-year period from 1913 to 1919, inclusive.*

Crop and variety.	Number of plat.	Unit of yield.	Yield per acre.									
			1920			1919	1918	1917	1916	1915	1914	1913
			Maximum.	Minimum.	Average.							
Alfalfa (Montana):												
Spring seeded	5	Ton	2.22	1.60	1.87	1.25	2.22	2.03	2.07	2.34	2.22	2.20
Fall seeded	4	do	3.82	2.91	3.38	2.63	3.17	3.42	.....	.....	.....	.....
Second year	9	do	5.67	3.49	4.59	6.09	5.34	5.71	5.26	7.14	5.40	5.85
Third year	5	do	6.08	5.27	5.68	4.24	6.13	5.38	6.26	7.00	5.26	5.35
Continuously cropped	5	do	5.14	4.36	4.65	5.77	5.45	4.65	4.98	4.72	4.62	4.51
Sugar beets (Kleinwanzlebener)	19	do	10.83	1.75	7.63	10.15	12.23	9.82	11.17	9.58	11.16	13.06
Potatoes (Mills Prize)	17	Bushel	226.6	58.6	136.4	249.3	367.6	218.2	240.3	301.8	167.8	212.7
Oats (Swedish Select)	21	do	99.5	31.5	63.6	52.7	90.7	75.0	78.2	79.3	89.8	84.2
Wheat (Pringle Champlain)	5	do	30.6	17.8	26.3	27.3	23.9	26.5	26.5	32.3	32.7	27.2
Corn (Northwestern Dent)	8	do	66.4	27.5	47.9	42.7	45.9	32.6	36.3	36.9	42.9	42.0
Flax (Minnesota No. 25)	2	do	18.1	6.0	12.0	8.5	20.2	18.9	17.7	21.3	18.6	21.7

While it is recognized that in the nature of this experiment a long term of years is required to obtain definite results, some indications of the effect of various crop sequences and of the value of alfalfa and manure in these rotations are becoming apparent. Table V gives the average yield of all crops in the rotation for each year from 1913 to 1920, inclusive, and also the maximum, minimum, and mean yields in 1920. The results indicate the wide variation in the

maximum and minimum yields of the different crops. The maximum yields are shown usually in the rotations which included alfalfa

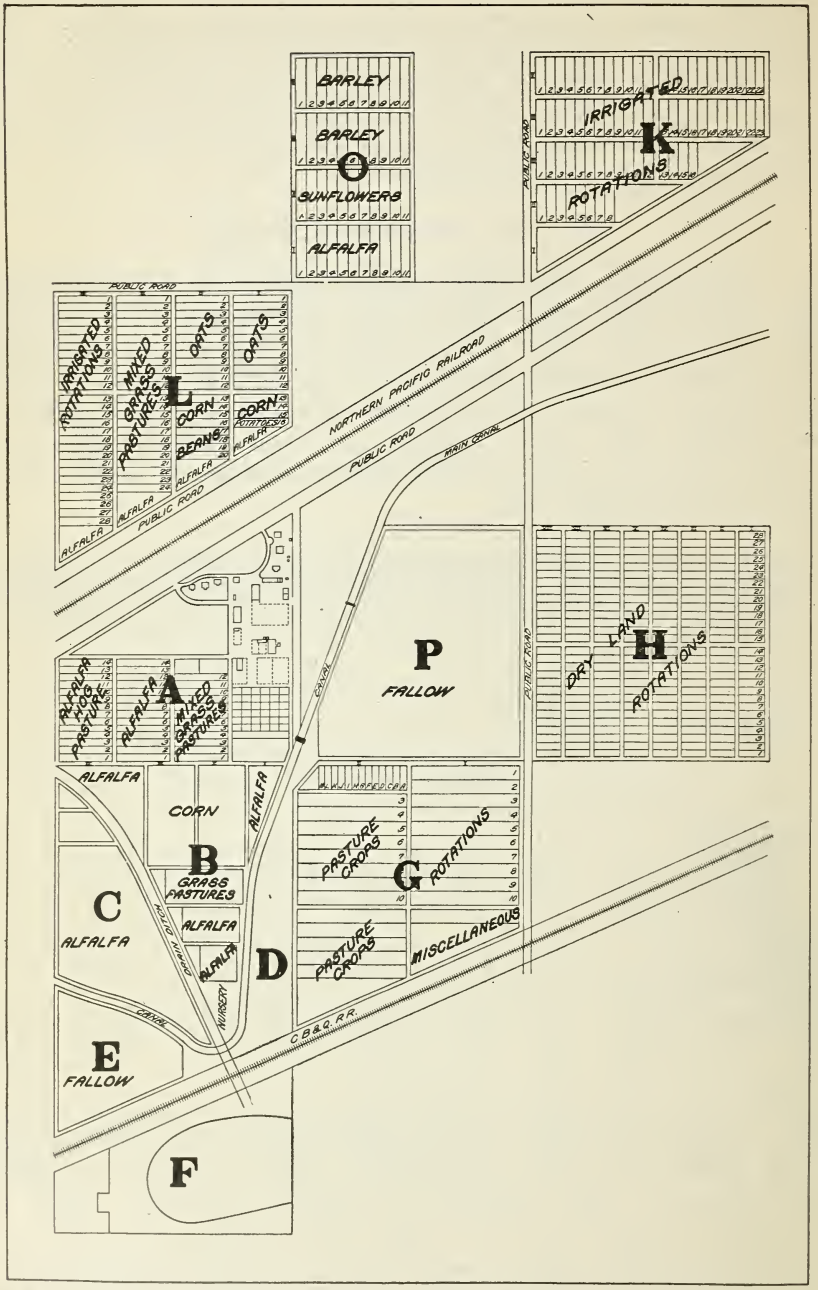

FIG. 2.—Diagram showing the arrangement of the fields and the location of the experiments at the Huntley Experiment Farm in 1920.

or manure, while the minimum yields are shown usually in the continuously cropped plats or in the shorter rotations.

Table VI presents in detail the yields of oats, potatoes, and sugar beets, as well as the preceding crop in each case, arranged in order of yield.

TABLE VI.—*Yields per acre of oats, potatoes, and sugar beets following stated crops in the irrigated rotations on the Huntley Experiment Farm in 1920.*

Oats.			Potatoes.			Sugar beets.		
Preceding crop.	Rotation No.	Yield.	Preceding crop.	Rotation No.	Yield.	Preceding crop.	Rotation No.	Yield.
		Bush.			*Bush.*			*Tons.*
Beets	35	99.5	Oats (manured)	25	226.6	Flax	67	10.83
Alfalfa	42	97.8	Do	35	222.6	Oats	60	10.13
Corn (hogged)	69	96.5	Oats	34	197.0	Oats (manured)	61	10.11
Beets	34	96.0	Alfalfa	64	196.0	Do	23	10.09
Do	46	86.3	Do	40	162.6	Do	31	9.98
Do	64	79.8	Do	60	160.3	Potatoes	21	8.17
Potatoes	60	73.8	Beets (manured)	21	124.0	Oats	42	8.14
Do	61	70.1	Beets	30	123.3	Do	32	8.11
Beets	22	70.0	Potatoes	4a	122.0	Potatoes	34	7.52
Oats	1a	59.5	Corn	26	116.0	Do	64	7.38
Beets	23	58.8	Beets	31	114.6	Do	35	7.27
Potatoes	44	58.5	Alfalfa	44	111.0	Do	20	6.71
Do	24	54.2	Beets	20	108.6	Oats	30	6.09
Do	25	53.0	Oats	24	106.6	Beets	2	5.89
Wheat	28	45.5	Alfalfa	61	90.6	Potatoes	40	5.75
Potatoes	31	43.6	Potatoes	4	78.6	Alfalfa	46	5.72
Corn	16	43.2	Oats (rye)	27	58.6	Beets	2a	1.75
Do	32	42.8						
Potatoes	30	40.8						
Do	27	36.0						
Oats	1	31.5						
Average		63.6	Average		136.4	Average		7.63

Oats produced the highest yields in rotations in which oats followed a cultivated crop and in which either alfalfa or manure or both are included.

Potatoes gave the maximum yield in a 2-year rotation in which potatoes followed oats, manured. The value of manure for this crop is indicated in the average yield of 224.6 bushels per acre in two rotations in which potatoes followed oats, manured, as compared with an average yield of 151.15 bushels in two rotations in which potatoes followed oats without manure. The next highest average yield of 144.1 bushels occurred in rotations in which potatoes followed alfalfa. The average yield of three plats of potatoes following beets was 115.5 bushels per acre. Two plats which are cropped continuously to potatoes yielded at the average rate of 100.3 bushels per acre.

The highest yield of sugar beets occurred in a 6-year rotation of three years of alfalfa followed by corn, flax, and beets. The third-year alfalfa in this rotation as well as the corn is hogged off. The yields of beets as well as other crops in this rotation have been consistently high and no doubt result largely from the effect of the hogging off of the alfalfa and corn crops.

SILAGE CROPS.

CORN.

A test of three varieties of corn for silage was conducted in duplicate on quarter-acre plats. These varieties were Northwestern Dent, Paynes White Dent, and a large yellow dent (variety not known). The average yields were at the rates of 6.73, 9.14, and 9.93 tons per acre, respectively. The season was unusually short for corn and the Northwestern Dent variety was the only one sufficiently matured for silage by September 15, the date of harvest. The two late varieties were in the soft-dough stage when harvested. The Northwestern Dent in all tests of former seasons in comparison with other early-maturing varieties has given the best results, and while some of the larger varieties may prove to be desirable to grow for silage, this variety from results so far obtained, is to be recommended for both silage and grain.

SUNFLOWERS.

In tests of Mammoth Black Russian sunflowers for silage during the four years from 1917 to 1920, inclusive, yields of 24 to 35 tons per acre were obtained, but during none of these years was the silage made from this crop of good quality, readily eaten by stock. These results are contrary to results with this crop in other parts of the State, where during the past few years sunflowers have been grown as a silage crop. An analysis made of sunflowers grown at the Huntley station in 1920 indicated that the plants were deficient in fermentable sugars and that they contained only about 2 per cent of such sugars, as compared to a content of 11 to 15 per cent of sugar in sunflowers in the Gallatin Valley, in which place silage of excellent quality is made from this crop. It would appear that this lack of sugar in the plants may be responsible for the failure during each of the four years to make good silage from sunflowers at the Huntley station. Cases of similar failure have been reported from other parts of the Yellowstone Valley, although in many other parts of the State, and especially in the higher valleys where corn can not be grown successfully because of the short growing season, sunflowers as a silage crop are reported to be giving excellent results.

Silage made from a mixture of sunflowers and corn in about equal proportions was of good quality and palatable to stock, the corn apparently containing sufficient sugar to cause proper fermentation in the mixture.

INVESTIGATIONS IN DRY-LAND AGRICULTURE.[1]

For the past nine years, 1912 to 1920 inclusive, the Office of Dry-land Agriculture has been carrying on a series of experiments with

[1] This report was prepared by Mr. Arthur E. Seamans, who had charge of the dry-land work of the station, being detailed for this work by the Office of Dry-Land Agriculture of the Bureau of Plant Industry.

various crops and soil-cultural methods on land above the ditch at this station.

At present the lines of investigation include the response of the more common field crops to various systems of crop rotation and cultural methods; studies of the behavior of soil moisture and its use by crops under different methods of tillage; pasturing work in which hogs are used to harvest a few of the common grain and grass crops; and variety tests and cultural methods with potatoes, beans, silage, fodder, and miscellaneous crops.

Field H contains 224 tenth-acre plats on which winter wheat, spring wheat, oats, barley, flax, corn, rye, peas, sweet clover, alfalfa, and brome-grass are grown in a series of rotations and methods of cultivation. On this field, also, are conducted the soil-moisture studies.

The pasture and miscellaneous crop experiments are confined to field G. The hog-pasturing experiments are conducted on plats 1 acre in area, the crops grazed being barley, peas, rye, corn, alfalfa, and brome-grass. Duplicate plats of these crops are harvested by machinery, and the returns for the two methods are compared. Twenty-four 1-acre plats are used in this work.

The miscellaneous crop experiments occupy 44 tenth-acre plats.

CONDITIONS INFLUENCING RESULTS.

Crop production under dry-land conditions is dependent upon a combination of several factors. In general, it may be said that the controlling factor is that of precipitation and more especially the precipitation that falls while the crops are growing. This may be called the seasonal precipitation. The distribution of this seasonal precipitation is another important feature. Good returns are sometimes produced on a comparatively light, though well-distributed seasonal rainfall; while low yields may be produced in a season having a comparatively heavy total precipitation which comes at a time or in such a manner as to be of little benefit to crops.

During the years of favorable precipitation, other climatic factors, such as evaporation, humidity, wind velocity, and temperatures, are also apt to be more favorable to plant growth and vice versa. Thus the season of 1915, a year of good yields, was characterized by a comparatively high seasonal rainfall that was well distributed, high humidity, low rate of evaporation, low wind velocity, and low temperatures; while in 1919 crop yields were very small, seasonal precipitation was considerably below normal, humidity was low, and evaporation, wind velocity, and temperatures were above normal.

The season of 1920, having a summer rainfall somewhat above the average, was prevented from producing high yields of all crops by the

unfavorable distribution of the precipitation. The greater percentage of this season's moisture fell in the early spring. At this time the soil was already saturated and much run-off occurred. A further disadvantage was the prevention of early planting and the maintenance of a cold, wet seed bed in which germination and early growth were slow. During the period in which most of the spring-sown crops were heading and the grain was filling, the much-needed rainfall was received in the form of dashing or torrential showers in which considerable amounts of water fell during short spaces of time. Such rains are of but little benefit to crops, for by packing the surface of the soil they often produce conditions more favorable to run-off than for penetration by the moisture.

This lack of available soil moisture at the time spring-sown grains were filling and the subsequent factors of low humidity, high temperatures, wind velocity, and evaporation resulted in yields which exceeded in most cases those received in 1918 and 1919 and yet were below the average returns of the 1913 to 1919 period.

Winter wheat, on the other hand, maturing nearly three weeks earlier than spring-sown small grains, gave yields that exceeded the general average for that crop. This can easily be accounted for by the early start received by the winter wheat, as compared with the other crops, and its maturity under favorable climatic and soil conditions.

The economical use of soil moisture together with favorable weather during the fall resulted in yields of corn closely approaching the average returns for that crop since 1913.

CROP RETURNS FROM ROTATIONS AND TILLAGE EXPERIMENTS.

Winter wheat.—The winter-wheat crop is probably the most reliable for this locality of any of the small grains produced without irrigation. The average yield of Kharkof winter wheat for 1920, from all rotations and methods of cultivation, was 28.7 bushels per acre. This is 7.9 bushels per acre above the average for the 6-year period from 1914 to 1919, inclusive. Summer fallow with an average yield of 30.7 bushels per acre was exceeded by the average returns from wheat disked in on clean-cultivated corn stubble. This method made an average of 34.4 bushels per acre. The 6-year normal for these two methods is 28.4 bushels per acre for fallow and 17.2 bushels per acre for disked corn land. Winter wheat produced on ground in which winter rye or field peas had been plowed under for green manure made an average of 29.8 bushels per acre for 1920, as against the previous 6-year normal of 22.8 bushels. Winter wheat on disked winter-wheat stubble made an average return of 25.1 bushels per acre on five plats in 1920. Winter wheat following winter wheat on five other plats that were plowed averaged 23.7 bushels per acre.

For the three years preceding, during which yields on disked winter-wheat stubble were obtained, the average of five plats on disked stubble was 7.1 bushels per acre and on five plowed plats following winter wheat, 5.5 bushels per acre.

Spring wheat.—The durum, or "macaroni," type of spring wheat, Kubanka variety, is used in the crop rotation and tillage experiments. For all methods in 1920 a yield of 12.4 bushels per acre was received from this crop. The 7-year average from 1913 to 1919, inclusive, was 17.1 bushels. Among the several experiments, spring wheat following peas, rye, or sweet clover plowed under for green manure averaged 15.3 bushels per acre in 1920. The 7-year average for this method was 19.9 bushels per acre. Spring wheat on disked corn land ranked second, with an average of 13.6 bushels for this year, as compared with a normal return of 16.6 bushels for former years. The yields on fall plowing averaged 12.7 bushels, while those from spring plowing were 11.2 bushels per acre. Though the average for summer fallow in 1920 was but 11.6 bushels per acre, the average produced by this method of cultivation for the past seven years has been 21.8 bushels per acre.

Oats.—The Sixty-Day variety of oats is used in the rotation and cultural experiments. This variety has made an average return of 36.8 bushels per acre for all methods during the 7-year period from 1913 to 1919, inclusive. The average yield in 1920 was 30.2 bushels per acre. The past seven years have given fall plowing an average return of 33.7 bushels per acre, while for the same period spring plowing has averaged 31.8 bushels. In 1920 the maximum average yield of oats was 39 bushels per acre from fall plowing. Spring plowing produced 25.3 bushels. Oats grown on summer fallow in 1920 made an average of but 34.9 bushels per acre, as compared with the normal yield of 49.2 bushels following this method. Disked corn land made 27.8 bushels per acre in 1920, while the average return for former years was 36.9 bushels. Oats after peas, rye, or sweet clover plowed under for green manure gave an average production of 31.7 bushels, while the 7-year normal for this method was 44.2 bushels per acre.

Barley.—The barley grown in these tests previous to 1920 was the White Smyrna variety. This is generally a comparatively high yielding variety, but because of its short straw in dry years harvesting is somewhat difficult. In 1920 the Hannchen variety was used. This variety probably ranks a close second to White Smyrna in point of yield in this region. It is somewhat taller growing and consequently more easily harvested. The average return for 1920 was 15.1 bushels per acre, and the 7-year normal is 26 bushels.

Barley probably suffered more from the droughty condition during the last part of the 1920 season than any other crops. The lowest yield, 4.2 bushels per acre, was on fallow. The yield after fall plow-

ing was 6.9 bushels, after spring plowing 13.1 bushels, on disked corn ground 15 bushels, and after green manuring 17.5 bushels. Previous to 1915 only three methods were under trial with this crop. The average yields of these for the 7-year period from 1913 to 1919, inclusive, were for spring plowing 19.3 bushels, on disked corn ground 24.6 bushels, and after green manure 33.1 bushels per acre. The work with barley was increased in 1914, and for the five years from 1915 to 1919, inclusive, there are results from two additional methods. The average yields for this 5-year period were for spring plowing 14 bushels, for fall plowing 14.8 bushels, on disked corn ground 19.8 bushels, on fallow 24.9 bushels, and for green manure 27.5 bushels per acre.

Flax.—The 7-year average yield, 1913 to 1919, inclusive, of flax is 8.7 bushels per acre in the various experiments on the dry-land plats. In 1920 this average was 5.3 bushels. Among the various methods, the average return of 7.4 bushels per acre for flax on disked corn ground was the maximum. Flax on fallow made 6.2 bushels this year as against the 7-year normal of 12.4 bushels. The difference between spring and fall plowing was slight, the yields from these methods being 5.9 and 5.2 bushels, respectively, in 1920. With the exception of fallow there has not been a considerable difference in the yield of flax on different treatments, but slightly the highest average has been on disked corn ground in a 5-year rotation.

Corn.—Northwestern Dent corn has been used from the first in the rotation and cultural experiments. The average yield of this crop for the 7-year period from 1913 to 1919, inclusive, was 22.6 bushels of grain and 1,846 pounds of dry stover per acre. In 1920 the yield averaged 20.2 bushels of grain and 1,766 pounds of stover per acre. As the greatest value of the corn crop in this region consists in the roughage produced and the economical seed bed for small grains resulting from the cultivation given the corn ground, the yields of this crop following a small-grain crop are more important from a practical standpoint than yields following summer fallow. The yield of corn following corn on both fall and spring plowing has averaged from 2 to 4 bushels less grain per acre than following small grains. Following the different small grains the yields have not been materially affected by which grain preceded or by whether the stubble was plowed in fall or spring. The 7-year average on spring-plowed winter wheat is 23.2 bushels, on spring-plowed barley 23.1 bushels, on spring-plowed oats 22.7 bushels, on spring-plowed spring wheat 21.9 bushels, on fall-plowed spring wheat 21.8 bushels, and on fall-plowed oats 21 bushels per acre. In 1920, corn grown on summer fallow made a return of 20.5 bushels of grain and 1,320 pounds of stover per acre. That produced on spring plowing was 20.4 bushels

of grain and 1,753 pounds of stover per acre. The 7-year average for fallow is 30.9 bushels of grain and 2,863 pounds of stover. Among the various methods of seed-bed preparation for corn, spring listing appears to be a desirable practice, from both the standpoint of labor involved and the yields returned. This method has to its credit an average yield of 26 bushels of grain and 1,787 pounds of stover.

Alfalfa.—Alfalfa grown in a rotation after grain for two and three years has produced during the 7-year period from 1913 to 1919 an average of 1,214 pounds of hay per acre for the 2-year-old fields and 1,367 pounds for the 3-year-old fields. The 1920 yields of this crop were 2,240 pounds of hay per acre for the 2-year-old meadow and 1,640 pounds for the 3-year-old planting.

Brome-grass.—Brome-grass grown in a meadow rotation after grain has produced a 7-year average of 523 pounds, 738 pounds, and 493 pounds of hay per acre on 1-year-old, 2-year-old, and 3-year-old plats, respectively, during the period from 1913 to 1919. In 1920 the 1-year and 2-year plats produced nothing, while the 3-year plat made 2,180 pounds of hay per acre.

EXPERIMENTS IN PASTURING DRY-LAND CROPS WITH HOGS.

The investigations in pasturing dry-land crops with hogs were started in 1915. At present they are being conducted with both annual and perennial crops, with the object of determining a system by which continuous summer pasture can be maintained. The annual crops are represented by winter rye, field peas, beardless barley, and corn. The perennial crops consist of alfalfa and brome-grass. Each crop is grown in duplicate plats, one of which is pastured and the other allowed to mature its crop. The matured crop is then harvested in the ordinary manner and the actual yields of grain and hay are found. The pasturing is done on the same plats every year, and the harvested crops are produced yearly on the same duplicate plats. In this way the cumulative effects of the pasturing are retained.

Annual crops.—The annual crops are arranged in the following 4-year rotation: Winter rye disked in on pea stubble, field peas on fall-plowed barley stubble, beardless barley on disked corn land, and corn on spring-plowed rye stubble. Each crop is grown on one of the plats in the rotation every year, advancing around the rotation cycle in the order named.

The acre of winter rye is usually ready for grazing sometime in May when the crop is 8 to 10 inches high. Ten fall pigs averaging 100 pounds each are turned into the rye. In addition to the pasturage, they receive a daily supplementary ration of corn at the rate of

2 pounds of corn per 100 pounds of live weight. The length of time the animals are on the rye pasture is limited by the growth of the crop. This period was an average of 57 days for the years 1916 to 1919, inclusive. In 1920, owing to the lateness of the season and the advanced stage of the forage, 15 pigs were used to pasture the rye. The pasture period lasted 42 days. The average daily gain per pig was 0.43 pound in 1920 as compared with 0.54 pound for the 4-year period from 1916 to 1919, inclusive. It required 5.6 pounds of corn to make a pound of pork in 1920, while the former average was 4.4 pounds of corn per pound of gain. The duplicate plat of rye yielded 13.2 bushels of thrashed grain in 1920, while the 4-year average yield is 10.3 bushels per acre.

At the close of the rye-pasturing period the pigs are moved from the rye plat to the plat of field peas. The crop is usually well advanced at this time, the plants being well filled with pods and the peas in the soft-dough stage. As the forage is largely of a succulent nature, the 2 per cent corn ration is continued. The average weight of the pigs at this stage of the experiment is 139 pounds. Usually the acre of peas is cleaned up, grain and vines, in about two weeks. The average length of time is 16 days, though the range is from 7 to 22 days, depending upon the crop. In 1920 the pasture period for peas was 20 days. Formerly it required an average of 2.2 pounds of corn to produce a pound of pork on the pea pasture, but this season the rate was 5.4 pounds of corn per pound of gain. This was due to the fact that the hailstorm of July 4 seriously damaged the crop by stripping the vines of many pods and leaves. The average daily gain per pig was but 0.5 of a pound in 1920, while the average for previous years was 1.3 pounds. A yield of 2.1 bushels of thrashed peas was obtained from the duplicate plat, as against an average of 4.7 bushels for former years. This average includes the year 1919, when no peas were harvested on the check plat.

Hogs from the plat of peas are turned into the barley plat (Success variety) after the pea forage is gone. At this time the average weight of the pigs is 160 pounds. The barley is approaching maturity and is considered more of a grain ration than a pasture, so no corn is fed. In 1919 no barley was produced because of the drought, and this phase of the experiment was omitted. The average length of time the hogs were on this plat, during the three years previous to 1919, is 15 days. During the three years 1916 to 1918, inclusive, but one year showed a gain in weight of the lot while on barley pasture. The gain this year averaged 0.71 pound for a pig each day. In 1920 the pasture period lasted 12 days, and during that time the 15 pigs made an average daily gain of 0.75 pound each. The 1920 yield of the check plat was 5.7 bushels per acre, while the 3-year normal was 9.6 bushels. The crop this year was badly dam-

aged by the hailstorm of July 4. This affected the yield from the harvested plat more than that of the hogged-off plat.

The plat of Northwestern Dent corn in this rotation is stocked with spring pigs, usually six in number, which during the past year averaged 86 pounds initial weight. They are placed on the corn plat when the grain is well dented and beginning to harden, and they remain there until the corn is cleaned up. Because of the drought in 1919 the corn plat was not pastured. The average length of time required to consume the corn has been 13 days for the 3-year period from 1916 to 1918, inclusive. In 1920 the corn crop was very good, and it took the six pigs 42 days to harvest the acre. The previous average daily gain has been 1.19 pounds per pig, but in 1920 this was 0.98 pound. The average yield of husked corn from the duplicate plat was 11.4 bushels for the three years, 1916 to 1918, while the yield this year was 14.4 bushels to the acre.

Perennial crops.—The alfalfa and brome-grass pastures were seeded in 1916, and the first grazing was done in 1917. Each crop is represented by two plats to be pastured. On one the forage is grown in rows 2 feet apart and on the other it is seeded broadcast. The system that has been followed is to stock the plats with fall pigs as early in the spring as conditions of growth and weather will permit and to continue the grazing until the forage is consumed or becomes unpalatable. Each lot of pigs received a supplementary daily ration of corn at the rate of 2 pounds of corn for every 100 pounds live weight.

The early results of the two methods of planting alfalfa for pasture have seemed to indicate that the broadcast plat is capable of carrying more hogs per acre than the row plat, though the average daily gains per pig made on the latter are a trifle more. These gains have been 0.72 pound for the row plat and 0.62 pound for the broadcast plat. The gains made have been at the expense of 2.9 pounds of corn per pound of gain for the row plat and 3.3 pounds of corn per pound of gain for the broadcast plat during the same average period of 57 days. The 1920 returns on the row plat for a period of 42 days show that four fall pigs with an average initial weight of 76 pounds made a daily gain of 0.63 pound each. It required 2.9 pounds of corn to make a pound of pork on this plat.

During the same period, beginning May 28, six fall pigs having an initial weight of 76 pounds made an average daily increase of 0.57 pound on the broadcast plat, and it took 3.2 pounds of corn to make a pound of pork. The check plats of alfalfa yielded 2,260 pounds of hay from the row plat and 1,146 pounds of hay from the broadcast plat.

The two plats of brome-grass pasture have been more nearly equal in carrying capacity than have the alfalfa. The average returns

from the row plat show a daily gain of 0.56 pound of pork at a rate of 4.2 pounds of corn per pound of gain. The pasture period for this plat averaged 60 days for five pigs. The broadcast plat has averaged 0.66 pound daily gain for the same number of pigs and the same length of time, with an outlay of 3.5 pounds of corn per pound of gain. The 1920 brome-grass pastures were very poor, as a result of the 1919 drought. Two pigs were used on each plat this year for a 42-day pasture period. The returns showed an average daily increase of 0.60 pound per pig from the row plat and 0.90 pound each per day from the broadcast plat. The corn ratio was at the rate of 3.3 pounds of corn per pound of gain on the row plat and 2.2 pounds of corn per pound of gain on the broadcast plat. The yield of brome-grass was 568 pounds per acre of weedy hay on the broadcast plat and nothing on the row plat.

CROP-UTILIZATION EXPERIMENTS.

PASTURING ALFALFA WITH HOGS.[2]

In rotation 67, field K, and in rotation 69, field L-IV, quarter-acre plats of third-year alfalfa are pastured with hogs. The pasturing season is divided into two periods, from April to July pastured with fall pigs, and from July to October pastured with spring pigs. Each plat is divided into two equal areas, and the hogs are alternated from one area to the other every 10 or 12 days.

TABLE VII.—*Results of pasturing pigs on alfalfa on the Huntley Experiment Farm during the 8-year period from 1913 to 1920, inclusive.*

[Calculations reduced to an acre basis. As only the third crop of alfalfa was pastured in 1913, the results for that year are not used in determining the averages.]

Year.	Rotation No.	Number of pigs.		Number of days.	Weight of pigs (pounds).				Grain fed per pound of gain (pounds).
		Spring.	Summer.		Initial.	Final.	Gain.		
							Total.	Average daily, per pig.	
1913	67	.....	46	41	2,788	3,624	836	0.50	2.65
1914	67	16	36	138	3,272	5,572	2,300	.42	2.78
1915	67	20	32	150	4,364	6,840	2,476	.70	3.13
1916	67	20	32	145	3,520	6,552	3,032	.85	2.79
1917	67	16	36	150	3,280	5,460	2,180	.74	2.87
1917	69	20	32	152	3,288	5,768	2,480	.72	2.64
1918	67	20	32	148	3,200	5,560	2,360	.66	2.72
1918	69	20	32	148	3,216	5,464	2,248	.63	2.85
1919	67	20	32	159	3,720	6,196	2,476	.57	2.99
1919	69	20	32	161	3,700	5,796	2,096	.48	2.45
1920	67	20	32	134	2,812	4,752	1,940	.56	2.57
1920	69	20	32	134	2,772	4,552	1,780	.55	2.83
Average		19.3	32.7	147.2	3,368	5,683	2,306	.63	2.87

[2] This report was prepared by Mr. Robert E. Hutton, who had charge of the animal-husbandry work of the station, being detailed for this work by the Animal Husbandry Division of the Bureau of Animal Industry.

The pigs are weighed every 14 days and with these weights as a basis they are fed 2 pounds of corn daily for each 100 pounds of live weight. The plats are pastured at the rate of 2,000 to 2,500 pounds of live weight of hogs per acre.

The late spring of 1920 reduced the grazing season to 134 days, which is 16 days less than the average length of season for 1914 to 1919, inclusive. The results obtained in pasturing alfalfa with hogs in rotations 67 and 69 for the 8-year period are shown in Table VII.

PASTURING CORN AND RAPE WITH HOGS.

The spring pigs used in the alfalfa-pasturing experiment in rotation 67 are used to hog off a quarter-acre plat of corn in the same rotation as soon as the summer pasturing period is completed. Table VIII gives the results obtained from hogging down the corn in rotation 67 for the past 9-year period.

TABLE VIII.—*Results of hogging-off corn on the Huntley Experiment Farm during the 9-year period from 1912 to 1920, inclusive.*

[Calculations reduced to an acre basis.]

Year.	Number of hogs.	Number of days.	Weight (pounds).				Estimated yield (bushels).
			Hogs.			Grain fed per 100 pounds of gain.	
			Initial.	Final.	Total gain.		
1912	20	16	2,900	3,288	388	530	36.4
1913	16	23	1,312	2,080	768	440	60.0
1914	16	22	1,380	2,276	896	320	50.4
1915	16	25	1,376	2,240	864	450	52.4
1916	16	20	1,516	2,188	672	500	60.0
1917	16	24	1,200	1,828	628	380	43.2
1918	16	27	1,428	2,152	724	510	65.0
1919	16	27	1,636	2,112	476	410	55.0
1920	32	22	2,652	3,444	792	469	66.4
Average	18.2	23	1,711	2,400	689	445	54.3

TABLE IX.—*Results of hogging-off corn and rape on the Huntley Experiment Farm for the 5-year period from 1916 to 1920, inclusive.*

[Calculations reduced to an acre basis.]

Year.	Number. of hogs.	Number. of days.	Weight (pounds).				Estimated yield (bushels).
			Hogs.			Grain fed per 100 pounds of gain.	
			Initial.	Final.	Total gain.		
1916	8	38	660	1,246	586	485	50.8
1917	16	22	1,168	1,700	532	433	41.4
1918	16	36	1,156	1,964	808	380	55.0
1919	16	29	1,116	1,930	814	241	60.0
1920	32	39	1,098	2,038	840	392	57.7
Average	17.6	32.6	1,039	1,755	716	386	52.9

In rotation 69 Dwarf Essex rape is drilled between the corn rows about the last of July. By the time the corn is mature in the fall the rape has made a good growth, and the hogs from the alfalfa-pasturing plat of the same rotation are turned in to harvest the corn and rape. Table IX gives the results obtained in hogging off the corn and rape for the 5-year period.

The results shown in Tables VIII and IX permit a comparison to determine whether it is worth while to sow rape in corn that is to be harvested by hogs. A comparison is made in Table X, which gives the averages for nine years in rotation 67, without rape, and for five years for rotation 69, with rape. This table shows that while the estimated yield of corn in rotation 69 has been somewhat lower than that for rotation 67, the total gains made have been higher for the rotation in which rape was sown with the corn. The annual variation from the means in the case of the grain required for each 100 pounds of gain has been so great that the differences in these means may not be regarded as very significant, but in four of the five cases it has required less corn to make the gain on the plat in which rape was sown.

TABLE X.—*Comparison of the results of hogging-off corn for five years with rape and for nine years without rape on the Huntley Experiment Farm.*

[Calculations reduced to an acre basis.]

Item of comparison.	Average results.	
	Nine years without rape.	Five years with rape.
Number of hogs per acre	18	17
Duration of experiment ... days	23	32
Total weight:		
Initial ... pounds	1,711	1,039
Final ... do	2,400	1,755
Gain ... do	689	716
Yield of corn (estimated) ... bushels	54.3	52.9
Estimated grain fed per 100 pounds of gain ... pounds	445	386

FEEDING EXPERIMENTS WITH HOGS.

Experiments with hogs were begun in 1917, in cooperation with the Animal Husbandry Division of the United States Department of Agriculture and the Montana Agricultural Experiment Station. The experiments conducted in 1920 included (1) a comparison of mill feed, tankage, and skim milk as supplements to corn for finishing fall pigs; (2) the feeding of various grain rations to hogs on alfalfa pasture, especially comparing corn alone with corn and tankage; (3) a comparison of light and heavy pasturing of alfalfa with spring pigs; and (4) finishing spring pigs in the dry lot on corn, tankage, and alfalfa.

A herd of pure-bred Duroc-Jersey hogs is maintained at the farm, and the pigs used in the feeding tests were practically all pure-bred Duroc-Jerseys. In addition to the pigs grown for experimental purposes, a number of the more desirable pigs were sold for breeding purposes, especially to the Boys' and Girls' Pig-Club members.

VARIOUS PROTEIN SUPPLEMENTS TO CORN FOR FATTENING PIGS.

On July 23 four lots of fall pigs were given an experimental test to determine the relative value of mill feed, tankage, and skim milk as supplements to corn for fattening pigs. Lot 1 received one part corn and three parts skim milk, lot 2 received corn and tankage in proportion of 23 to 4, lot 3 received one part corn and three parts mill feed, and lot 4 had one part corn, one part mill feed, and two parts skim milk. All the lots were on full feed throughout the test. The results of this experiment are given in Table XI. This table shows that lot 1 made more rapid gains and required less concentrates per 100 pounds of gain than any of the other lots. The corn and tankage lot produced 100 pounds of gain on 49 pounds less feed than the corn and mill-feed lot. In figuring the value of one feed in terms of another as based on this experiment the following results are obtained: In lot 1 every 5.2 pounds of skim milk fed was equal to 1 pound of grain and in lot 4, where less milk was fed, every 3.3 pounds of milk fed saved 1 pound of grain. This shows that a small proportion of milk will have a greater value per pound than larger amounts, but it does not mean that milk if available should be fed sparingly, as the total value of a larger amount of milk will always be the greater. The conclusions to be drawn from this test are that where skim milk is available it is the best supplement to corn for fattening pigs and that tankage is a better protein supplement than mill feed for fattening hogs.

TABLE XI.—*Results of feeding various protein supplements to corn for fattening fall pigs (in lots of six each) on the Huntley Experiment Farm.*

[Duration of experiment, 57 days.]

Item.	Lot 1, 1 part corn, 3 parts skim milk.	Lot 2, 23 parts corn, 4 parts tankage.	Lot 3, 1 part corn, 3 parts mill feed.	Lot 4, 1 part corn, 1 part mill feed, 2 parts skim milk.
Average weight per pig:				
Initial ..... pounds..	115.3	116.1	116.5	116
Final ..... do....	195.6	175.5	181	191.1
Gain ..... do....	80.3	59.4	64.5	75.1
Average daily gain ..... do....	1.41	1.04	1.13	1.32
Total gain per lot ..... do....	482	356	387	451
Feed consumed:				
Corn ..... do....	1,557	1,538	532	954
Mill feed ..... do....	.....	.....	1,614.1	954
Tankage ..... do....	.....	261.8	.....	.....
Skim milk ..... do....	4,611	.....	.....	1,908
Feed per 100 pounds of gain:				
Concentrates ..... do....	323	505	554	423
Skim milk ..... do....	956	.....	.....	423

SPRING PIGS ON ALFALFA PASTURE WITH VARIOUS GRAIN RATIONS.

Six lots of spring pigs were placed on alfalfa pasture on July 27, after the first cutting had been harvested. Lot 1 consisted of eight pigs on one-half acre of pasture, receiving no grain; lot 2, eight pigs on one-quarter acre, receiving 2 pounds of grain daily for each 100 pounds of live weight; lot 3, eight pigs on one-quarter acre, receiving 2 pounds of corn and tankage daily for each 100 pounds of weight; lot 4, eight pigs on one-quarter acre of pasture, having access to corn in a self-feeder; lot 5, eight pigs on one-quarter acre, having access to corn and tankage in a self-feeder; lot 6, two pigs on one-quarter acre of pasture, receiving a 2 per cent corn ration. The pigs were on pasture until October 1, a pasture period of 67 days. The results of this experiment are given in Table XII. This table shows that the lot of pigs receiving no grain made very little gain during the pasture period; one pig in this lot died while on pasture, in all probability because of the fact that it was not properly nourished. Comparing lots 2 and 4 with lots 3 and 5, the two lots receiving corn and tankage made slightly more rapid gains than the lots receiving the corn alone. The lot having 2 per cent corn required more feed per 100 pounds of gain than the lot having 2 per cent corn and tankage, while the two self-fed lots required the same amount of feed per 100 pounds of gain. This shows that there is a slight advantage in feeding tankage with corn for spring pigs on alfalfa pasture. A comparison of lots 2 and 3 with lots 4 and 5 shows that the self-fed lots made much more rapid gains than the 2 per cent lots, but required about one-tenth more feed for each 100 pounds of gain. However, the self-fed lots made so much more gain per acre of pasture that the 10 per cent excess of grain consumed was more than offset by the lower cost of the pasture for each 100 pounds of gain.

TABLE XII.—*Spring pigs on alfalfa pasture with varying grain rations on the Huntley Experiment Farm in 1920.*

[Area of pasture for lot 1, one-half acre; for all other lots, one-fourth acre each].

Items of comparison.	Lot 1, no grain.	Lot 2, 2 per cent corn.	Lot 3, 2 per cent corn and tankage.	Lot 4, self-fed corn.	Lot 5, self-fed corn and tankage.	Lot 6, 2 per cent corn.
Number of pigs	8	8	8	8	8	2
Average weight per pig:						
Initial ... pounds	64.75	65.75	65.62	65.9	66	65
Final ... do	65.62	101.6	102.5	134.5	142	121
Daily gain ... do	.01	.53	.55	1.02	1.13	.83
Gain per acre ... do	14	1,148	1,180	2,196	2,432	448
Grain fed per 100 pounds of gain ... do	.....	301	289	322	322	205

Lot 6 of this series consisted of two pigs on one-quarter acre of pasture which was only one-fourth as many pigs per acre as lots

2, 3, 4, and 5. This lot required 94 pounds less feed for each 100 pounds of gain than the lowest of the other four lots. Lot 6 received the same amount of corn per pig as lot 2, and the two lots are identical in every respect except that lot 2 was pastured at the rate of 32 pigs per acre and lot 6 at the rate of 8 pigs per acre. As shown in Table XII, lot 6 made 0.3 of a pound more gain per day per pig and required only 205 pounds of grain for 100 pounds of gain, while lot 2 required 301 pounds of feed per 100 pounds of gain.

FINISHING HOGS IN A DRY LOT ON CORN, TANKAGE, AND ALFALFA HAY.

On October 1 the six lots of spring pigs on alfalfa pasture shown in Table XII were removed from the pasture and each lot placed on a self-fed ration of shelled corn, tankage, and alfalfa hay in a dry lot. The object of this experiment was to show the results obtainable in finishing pigs which had received various grain rations while on pasture. As soon as each lot of pigs reached an average weight of 200 pounds per head they were removed from the experiment and sold. The length of the finishing period necessary to bring them to 200 pounds in weight varied from 43 days for the two lots which had been self-fed on pasture to 85 days for the lot which had received no grain on pasture. All of the lots were readily put on full feed except lot 1, the pigs that had received no grain on pasture.

Table XIII shows the combined results obtained with the six lots from the time they were put on pasture until they were finished for the market. It will be seen from this table that the number of days necessary to bring the pigs from 65 pounds initial weight to 200 pounds final weight varied from 103 days for lot 5, which received self-fed corn and tankage on pasture, to 149 for lot 1, which received no grain while on pasture. The pigs which were marketed in 103 days required much less labor than the pigs which required 149 days to reach a marketable weight, and also this year there was a material reduction in the market value of hogs between the dates of the first and last marketings. It will be seen from Table XIII that lot 6, consisting of two pigs on one-quarter acre of alfalfa pasture, made the most economical gains of any. There was very little difference in the consumption of grain per 100 pounds of gain in lots 2, 3, 4, and 5. It required 25 pounds more feed per 100 pounds of gain in the 2 per cent corn lot than it did in the 2 per cent corn-and-tankage lot and 6 pounds more in the self-fed corn lot than in the self-fed corn-and-tankage lot, showing that the addition of tankage to the ration reduced slightly the feed necessary to produce 100 pounds of gain. There is very little difference in the feed for 100 pounds of gain between the lots fed a 2 per cent ration on pasture and those on full feed, 14 pounds more feed per 100 pounds of gain being required in the 2 per cent corn lot than in the self-fed corn lot and 6 pounds

less feed in the 2 per cent corn-and-tankage lot than in the self-fed corn-and-tankage lot. However, the early marketing and the more pork produced per acre are additional advantages of the self-fed method for spring pigs on alfalfa pasture.

TABLE XIII.—*Spring pigs on alfalfa pasture with varying grain rations and in dry lot on the Huntley Experiment Farm in 1290.*

[Area of pasture for lot 1, one-half acre; for all other lots, one-fourth acre each.]

Item of comparison.	Lot 1, no grain.	Lot 2, 2 per cent corn.	Lot 3, 2 per cent tankage.	Lot 4, self-fed corn.	Lot 5, self-fed corn and tankage.	Lot 6, 2 per cent corn.
Number of pigs	[a] 7	8	8	8	8	2
Pasture period.....days	67	67	67	67	67	67
Dry-lot period.....do	85	64	64	43	43	43
Total	152	131	131	110	110	110
Number of days required to bring pigs to 200 pounds	149	130	127	110	103	108
Average weight:						
Initial.....pounds	64.75	65.75	65.62	65.9	66	65
At end of—						
Pasture season.....do	65.62	101.6	102.5	134.5	142	121
Final dry-lot period.....do	204	201.7	205.5	200.6	212.2	203
Daily gain—						
Pasture.....do	.01	.53	.55	1.02	1.13	.83
Dry lot.....do	1.52	1.57	1.61	1.54	1.63	1.91
Entire period.....do	.92	1.04	1.06	1.22	1.29	1.25
Feed for each 100 pounds of gain:						
On pasture.....pounds	.....	301	289	322	322	205
On dry lot.....do	494	418	398	430	409	399
Entire period.....do	489	387	362	373	373	322

[a] One pig died in lot 1 while on pasture.

PASTURING EXPERIMENTS WITH DAIRY COWS.[3]

Experiments with various pasture mixtures on irrigated land which have been conducted since 1912 show conclusively that such lands can be profitably used for this purpose and that well-established pastures when properly cared for have a carrying capacity during the grazing period of 4½ to 5 months, at the rate of 1½ to 2 cows per acre. From the experiments so far conducted it is possible to recommend a fairly standard pasture mixture, and pastures have been successfully started by seeding in the spring, both with and without a nurse crop of wheat, as well as by late summer seeding in grain stubble. The latter method appears to be most popular with farmers on the Huntley project, although spring seeding is practiced to some extent and usually with success.

CARRYING-CAPACITY TESTS WITH DAIRY COWS.

From the results of preliminary tests made of a number of separate grasses and grass mixtures a selection of three promising mixtures was made, and these were seeded in 1916 and later used in a

[3] This report was prepared by Mr. J. B. Shepherd, who was detailed by the Dairy Division of the Bureau of Animal Industry to have charge of the work with dairy cattle.

comparative carrying-capacity test for dairy cows. These mixtures and the rate of seeding of each of the grasses and clovers in each are given in Table XIV.

TABLE XIV.—*Pasture mixtures and rates of seeding in a carrying-capacity test with dairy cattle on the Huntley Experiment Farm in 1920.*

Pasture mixtures.	Rate per acre of seeding (pounds.)		
	Mixture No. 1.	Mixture No. 2.	Mixture No. 3.
Awnless brome-grass	2	2	.....
Orchard grass	5	5	5
Tall fescue	3	3	3
Perennial rye-grass	3	3	.....
Kentucky bluegrass	4	4	4
White clover	2	.....	2
Alsike clover	2	.....	2
Seed per acre	21	17	16

There were 2 acres of each pasture mixture, and the pastures were divided in each case for alternate pasturing and irrigation. The grazing experiment was not begun until 1918, and hay was harvested from the pastures in 1917.

During the course of the experiment it was necessary to include in each lot cows that were dry, since the number of cows in the herd was limited and not enough cows in milk were available for all the pasture experiments. The cows in milk were assigned in as nearly equal numbers as was possible to the different lots with regard to length of lactation period, previous and present production, weight, and date of next calving.

In 1918 a crop of hay was harvested from the pastures before May 22, the date the pasturing experiment was begun. The pasture season on mixtures No. 1 and No. 3 closed on October 12, and covered a total period of 144 days. On mixture No. 2 the pasture season closed October 2, because of short pasturage, so that the pasture period on this mixture was only 134 days.

Three cows were placed on each mixture at the beginning of the test. A fourth cow was added to each group on June 10, as it was found that three cows could not keep the pastures grazed closely enough. The fourth cow was removed on August 22, only three cows remaining in each group after that date.

Two cows on mixture No. 1 were producing milk during the entire pasture season, but the third cow was dry throughout the season. The fourth cow which was placed on each mixture from June 10 to August 22 was in each case a dry cow. On mixture No. 2 there were three cows producing milk, but they were taken from pasture and removed from the experiment 10 days earlier than the cows on mix-

tures No. 1 and No. 3. On mixture No. 3 two cows were producing milk part of the season, the third cow being dry.

In 1919 the cows were placed on pasture on May 8, four cows in each group. One cow was removed from mixtures Nos. 1 and 2 on June 23, and one cow from mixture No. 3 on June 25. The three cows remaining in each group were carried on the pasture for the remainder of the pasture season with the exception of one week beginning July 9, when they were all removed to allow the pasture to recover from too-close grazing. The pasture season extended to September 28, or a period of 141 days.

All four cows on each mixture were milking at the beginning of the pasture season. Of the three cows which were on mixture No. 1 during the entire season, two continued to give milk until they were taken off pasture, the third cow going dry on September 10. Two of the three cows on mixture No. 2 were giving milk throughout the season, the third cow going dry August 13. Two cows on mixture No. 3 were milked throughout the season, the third going dry August 13. The cow removed from each mixture the latter part of June was milked during the time she was on the experiment.

The 1920 pasture season began on May 14, and closed on September 27, extending over a period of 137 days, except for mixture No. 2, from which the cows were removed on September 24, after a grazing period of 134 days. Four cows were placed in each group at the beginning of the season. This number was found insufficient to keep the pasture grazed down, and on May 17 additional cows were added to each group for temporary periods. On July 4 one cow was removed from each group, leaving three cows in each until the close of the experiment. Rain and a hailstorm on July 4 damaged the pastures to such an extent that it was necessary to remove the cows and feed them hay until the 18th of July. They were also fed hay from August 29 to 31, inclusive.

Two cows in each group were giving milk at the beginning of the season, the other two in each case being dry. There were two cows in milk on mixture No. 1 until August 29, when one cow went dry. The two cows in milk on mixture No. 2 continued to give milk until the close of the experiment. On mixture No. 3, one of the two cows that were giving milk went dry on July 14. The additional cows placed on each mixture for limited periods were all dry cows.

The pasture in each part of the experiment was divided and each part pastured alternately for a period ranging from five days to two weeks, depending upon the pasturage conditions. Until early in September, when irrigation ceased, each part of the pasture was irrigated soon after the cows were removed to the alternate pasture.

Table XV gives the results per acre obtained from each of the three pasture mixtures in 1918, 1919, and 1920.

TABLE XV.—*Results of pasturing experiments with dairy cows on the Huntley Experiment Farm in 1918, 1919, and 1920.*

Items of comparison.	Mixture No. 1.				Mixture No. 2.				Mixture No. 3.			
	1918	1919	1920	Average.	1918	1919	1920	Average.	1918	1919	1920	Average.
Length of grazing season.....days..	144	141	137	141	134	141	134	136	144	141	137	141
Grazing period per acre.....do....	253.5	239.5	249.5	247.5	238.5	239.5	238.5	238.8	258.5	240.5	268.5	255.8
Alfalfa hay fed while cows were off pasture..pounds..	1,475	536	1,908.7	1,306.5	1,115	513	1,794.7	1,140.9	1,530	542	1,862.4	1,311.5
Grazing period of cows on outside pasture.....days..	.....	.....	12	12	.....	.....	15	15	.....	.....	15	15
Average daily number of cows per acre.....	1.76	1.70	1.82	1.76	1.78	1.70	1.78	1.75	1.80	1.71	1.97	1.83
Average gain in weight per cow during season, pounds.....	115	125.6	172	137.5	64	39.2	121	74.4	44	112.3	188	114.8
Milking period per acre.....days..	159.5	227.5	123.5	170	201	213.5	133	182.5	85	214.5	98.5	132.7
Production per acre:												
Milk.....pounds..	3,016.2	4,527.8	3,192	3,578.7	4,041.6	3,789.5	2,447.8	3,426.3	2,587.8	3,998.9	1,560.9	2,715.8
Butter fat.....do....	105.04	168.05	111.96	128.35	129.96	137.61	97.37	121.65	83.95	128.62	56.46	89.68
Skim milk.....do....	2,666.3	3,967.4	2,819	3,150.9	3,609.1	3,330.8	2,123	3,020.9	2,308.3	3,570.2	1,373	2,417.2
Hay.....do....	2,674	.....	.....	2,674	2,140	.....	.....	2,140	1,278	.....	.....	1,278
Values per acre:												
Butter fat.....	$44.94	$90.58	$58.22	$64.57	$53.86	$74.17	$50.63	$59.55	$36.80	$69.33	$29.36	$45.16
Skim milk.....	13.33	19.83	14.09	15.75	18.05	16.65	10.61	15.10	10.54	17.85	6.86	11.75
Total of butter fat and skim milk.....	58.27	110.41	72.31	80.32	71.91	90.82	61.24	74.65	47.34	87.18	36.22	56.91
Hay at $15 per ton.....	20.05	.....	.....	6.68	16.05	.....	.....	5.35	9.58	.....	.....	3.19
Total of butter fat, milk, and hay.....	78.32	110.41	72.31	87.00	87.96	90.82	61.24	80.00	56.92	87.18	36.22	60.10
Hay fed ($15 per ton in 1918 and 1919; $20 per ton in 1920).....	11.06	5.36	7.15	7.86	8.36	5.15	6.73	6.75	11.47	5.42	6.98	7.96
Outside pasture used ($3 per cow per month).....	.....	.....	1.20	.40	.....	.....	1.50	.50	.....	.....	1.50	.50
Total hay fed, pasture used.....	11.06	5.36	8.35	8.26	8.36	5.15	8.23	7.25	11.47	5.42	8.48	8.46
Net returns per acre.....	67.26	105.05	63.96	78.74	81.60	85.67	53.01	72.75	45.45	81.76	27.74	51.64

The number of grazing days denotes the total number of days the cows were pastured on each acre. The number of milking days denotes the number of days that cows in milk were on the experiment.

The value of the butter fat was obtained from the actual average price received in each case, being, in 1918, 42.8 cents per pound for cows on pasture mixture No. 1; 41.44 cents for those on mixture No. 2; and 43.82 cents for those on mixture No. 3. In 1919 the average price received during the pasture season was 53.9 cents per pound. In 1920 the average price received during the pasture season was 52 cents. Skim milk was uniformly valued at 50 cents per 100 pounds.

The cows were off pasture during stormy weather, when pastures were short, or on account of injury to a cow, and at night after August 28, 1918, September 14, 1919, and September 1, 1920. It was during these periods that the hay noted in Table XV was fed.

The larger net income per acre received from pasture mixture No. 2 in 1918, which was $81.60, as compared with $67.26 for mixture No. 1 and $45.45 for mixture No. 3, was undoubtedly due to the longer period that cows in milk were on that pasture mixture. That is also true for the 1920 season. In 1919 the production results from the different pasture mixtures were more nearly the same, corresponding closely with the number of milking days per acre. Since the number of milking days was larger in 1919 and butter fat had a greater value per pound, greater net returns were secured in each instance over 1918 and 1920. While the average number of cows per acre differed very little on all of the mixtures, it was apparent from observation that the amount and growth of the pasture on mixtures Nos. 1 and 3, which both contained clover, were greater than for mixture No. 2, and it was also evident that the addition of a small amount of clover increased the production of the pastures.

In this experiment, the object was to determine the carrying capacity of each mixture, production being a minor consideration. Another experiment was conducted in 1919 and 1920 to determine the maximum carrying capacity of an acre of irrigated land and also to secure the largest production of milk and butter fat possible.

CARRYING CAPACITY OF AN ACRE OF IRRIGATED PASTURE.

A pasturing experiment with dairy cows to determine the maximum carrying capacity of an acre of irrigated pasture was conducted in 1919 and 1920.

In this experiment 1 acre of mixed-grass pasture in field A, seeded to pasture mixture No. 1, was used. This pasture was seeded in 1916 and top-dressed with manure at the rate of 12 loads per acre in 1917, 1918, and 1919. The pasture was divided and each part pastured alternately in periods ranging from 5 to 10 days.

In 1919 the pasture season began on May 8 and ended on September 28, a period of 141 days. The pasture in 1920 covered a period of 137 days, beginning on May 14 and ending on September 27. Two cows were carried on the acre throughout both pasture seasons with the exception of one week in 1919, beginning July 9, and three days in 1920, beginning July 5.

In 1919 the cows used in this test were giving milk during all the time they were on the experiment. The gains in the weight of the cows during the experiment were but slight, although they were maintained in good condition.

In 1920 two cows were used in the experiment, a third cow being required for eight days beginning May 16. One of the two cows went dry on August 20. The additional cow was giving milk at the time she was on the experiment. Table XVI gives the results of this test.

TABLE XVI.—*Carrying capacity of an irrigated pasture on the Huntley Experiment Farm in 1919 and 1920.*

Items of comparison.	1919	1920	Average.
Length of grazing season ..... days..	141	137	139
Grazing period ..... do....	279	282	280.5
Alfalfa hay fed while off pasture ..... pounds..	768	750.7	759.3
Grazing period on outside pasture ..... days..	.....	6	.....
Average daily number of cows	1.98	2.06	2.02
Average gain in weight per cow ..... pounds..	.....	119	.....
Milking period per acre ..... days..	275	244	259.5
Production per acre:			
Milk ..... pounds..	5,992.5	6,344.8	6,168.6
Butter fat ..... do....	199.12	304.68	251.9
Skim milk ..... do....	5,328.8	5,229	5,278.9
Values per acre:			
Butter fat	$100.40	$158.43	$129.41
Skim milk	26.64	26.15	26.39
Total	127.04	184.58	155.81
Alfalfa hay fed	7.68	5.63	6.65
Outside pasture consumed	.....	.60	.....
Net returns per acre	119.36	178.35	148.85

Table XVI indicates that the average carrying capacity of this pasture was at the rate of about two cows per acre during the grazing season of 139 days and that the carrying capacity was increased by about one-fourth by the application of a top-dressing of manure.

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